

LECTURE 5

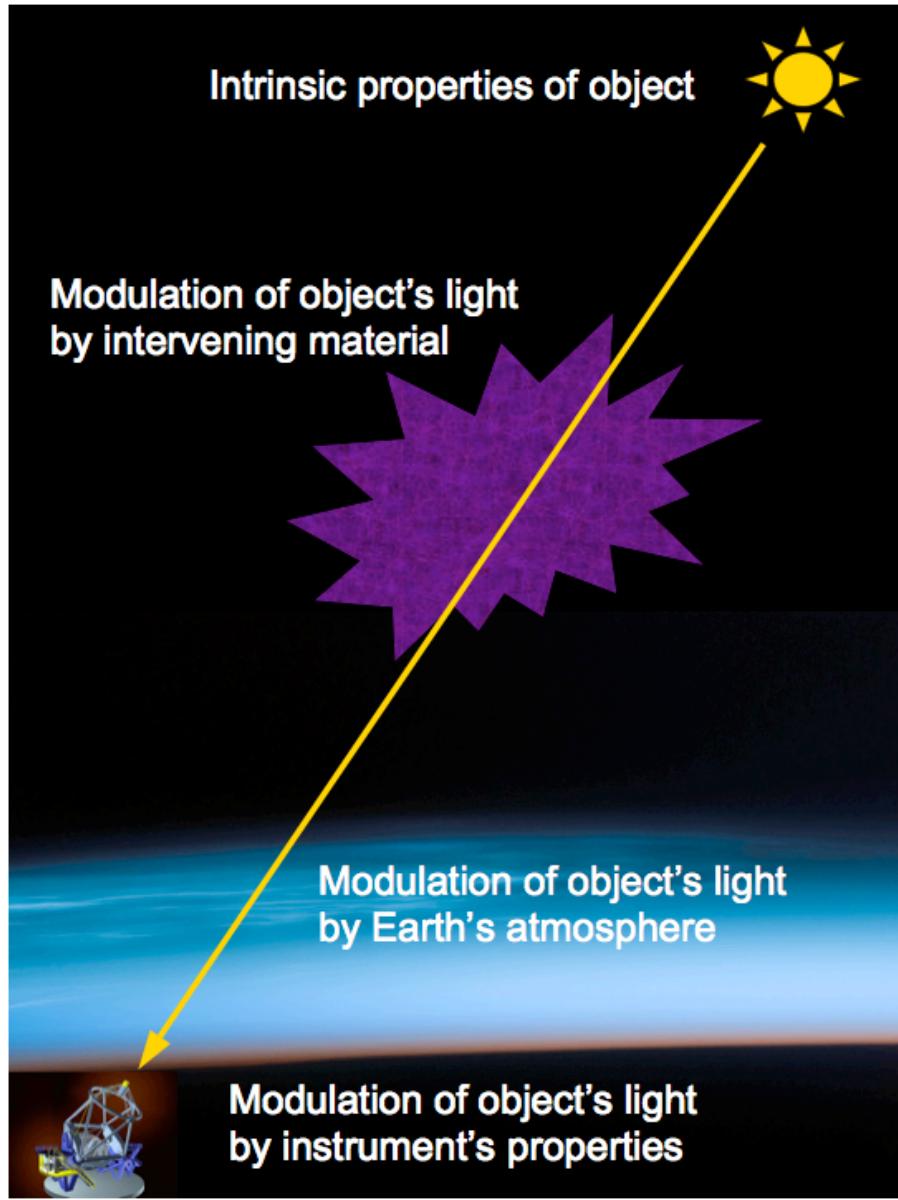
Data and Error Analysis

The goal of observational astronomy is to determine the intrinsic properties of a source from the observed properties.

Observables

- magnitude → luminosity
- colour → temperature
- redshift → velocity, distance
- polarization → magnetic field
- spectral lines → chemical composition
- light curve → orbital parameters

What changes an intrinsic property into an observable?



Source

Dust
Gas
Magnetic fields

Seeing
Absorption

Detector sensitivity
Pixel size
Timing resolution

Environment of the source

- Embedded in a star-forming region
- Herbig-Haro object
- Stellar wind
- Supernova remnant
- Warped spacetime
- Etc.

Intervening material

- Interstellar dust
- Interstellar gas
- Magnetic fields

Dust and gas are fairly well mapped in the Galaxy.

Relativistic and Cosmological Effects

- Redshift due to expansion of the Universe
- Time dilation
- Brightness not following a $1/R^2$ law

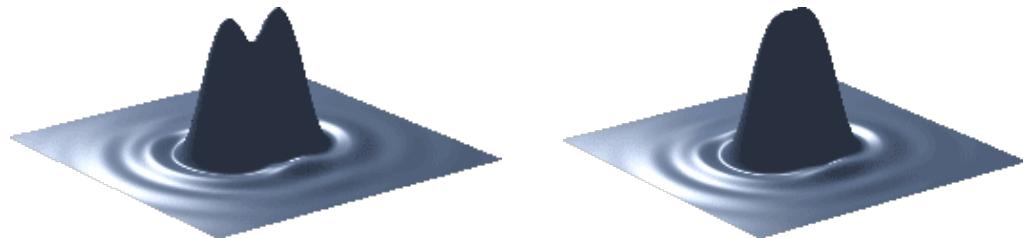
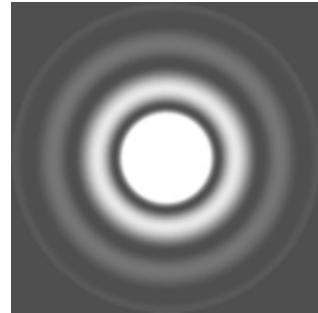
Atmospheric Effects

- Turbulence → seeing
- Transparency
 - Some wavelengths are blocked
 - Attenuation
- Atmospheric spectral lines (telluric lines)

Telescope and Instruments

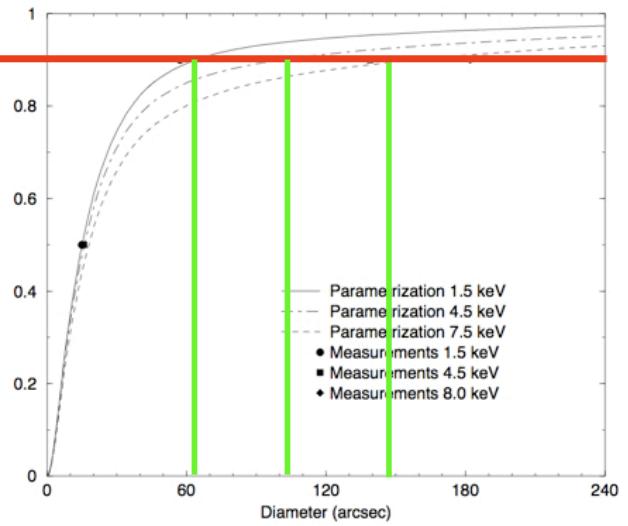
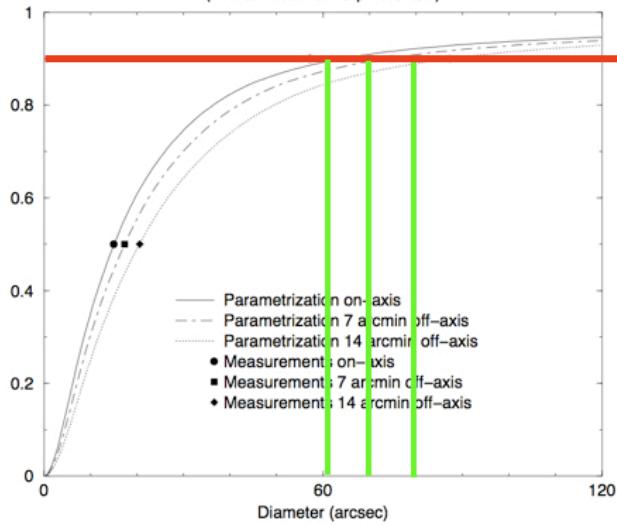
- Mirrors
 - Diffraction limit
 $\theta = \lambda/D$ (rad)
- Internal reflections
- Vignetting
- Detector
 - Pixel size
 - Sensitivity as a function of wavelength

Spatial Resolution



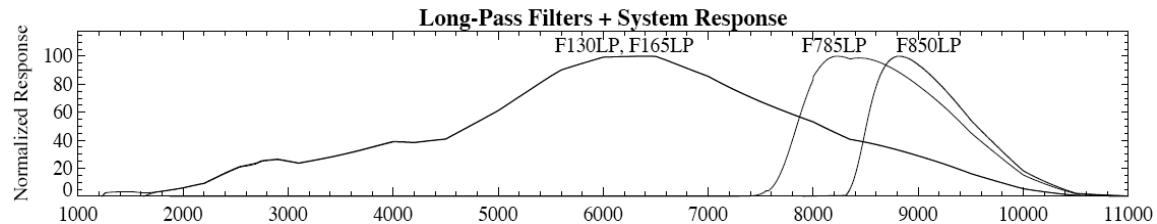
Encircled energy function

(XRT3 / FM2 / EPIC pn 1.5 keV)



Wavelength Transmission

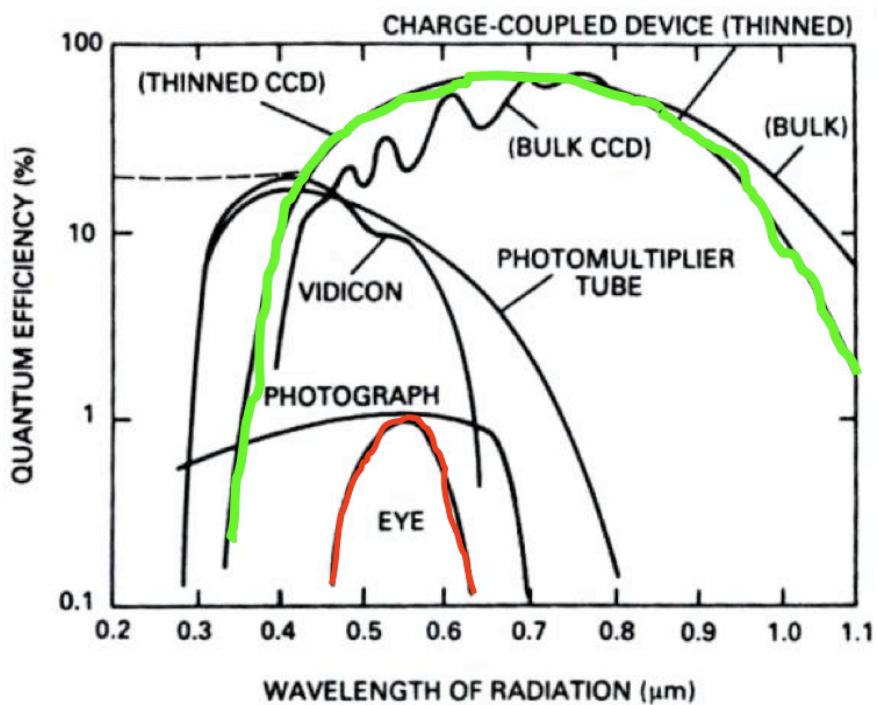
Filter response curves



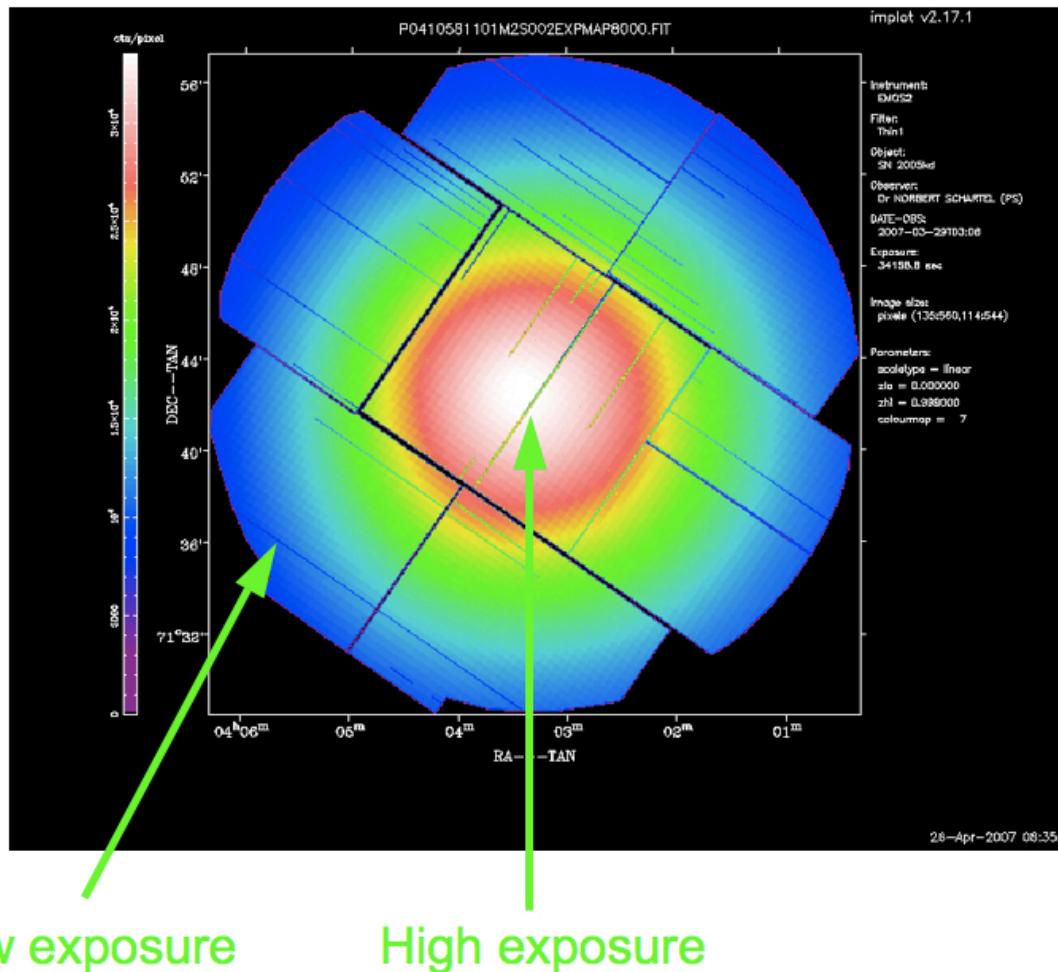
Keck II/NIRC2 Filters

Filter	Central wavelength (μm)	Bandpass Width (μm)	Cut-On Wavelength (μm)	Cut-Off Wavelength (μm)	Photometric Zeropoint	Sky (mag/sq. arcsec)	T(max) (sec)
J	1.248	0.163	1.166	1.330	25.35	14.9	10 000
H	1.633	0.296	1.485	1.781	25.44	13.6	2750
K	2.196	0.336	2.028	2.364	24.63	12.6	630
Ks	2.146	0.311	1.991	2.302	24.53	12.2	630
Kp	2.124	0.351	1.948	2.299	24.74	12.2	630
Lp	3.776	0.700	3.426	4.126	23.2	2.91	0.27
Ms	4.670	0.241	4.549	4.790	21.2	-0.12	0.14

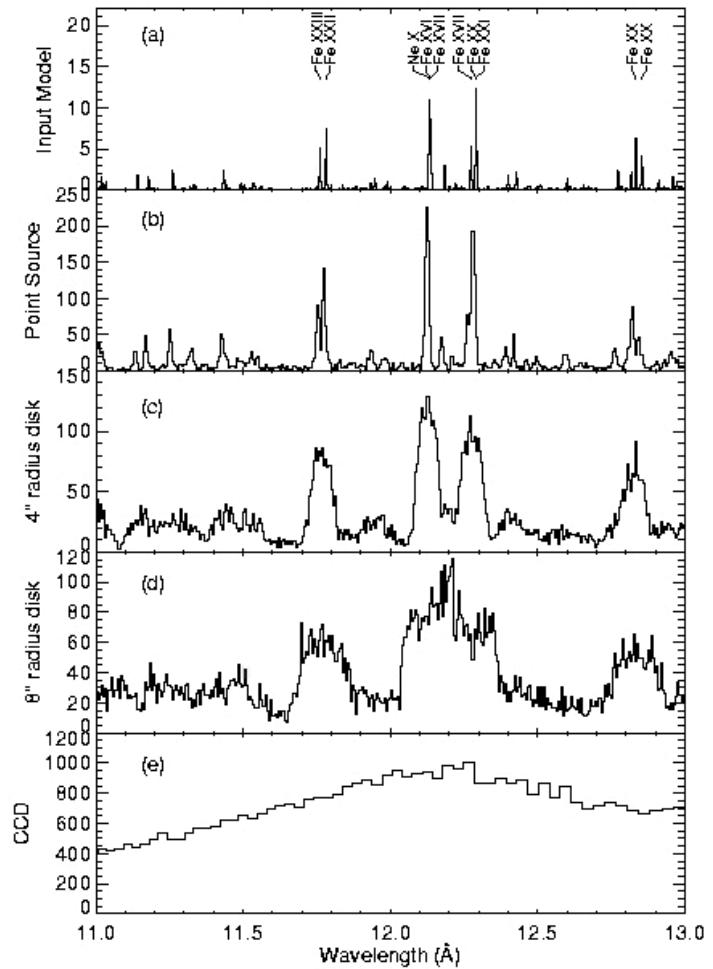
Quantum Efficiency



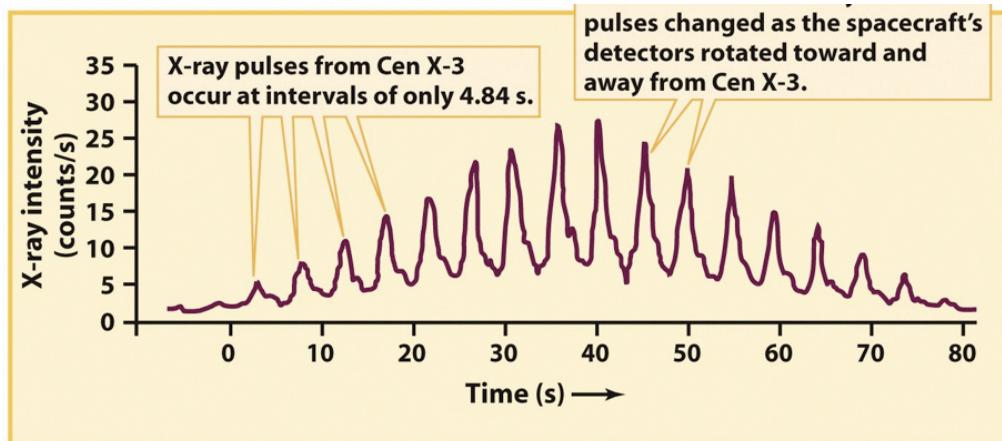
Vignetting



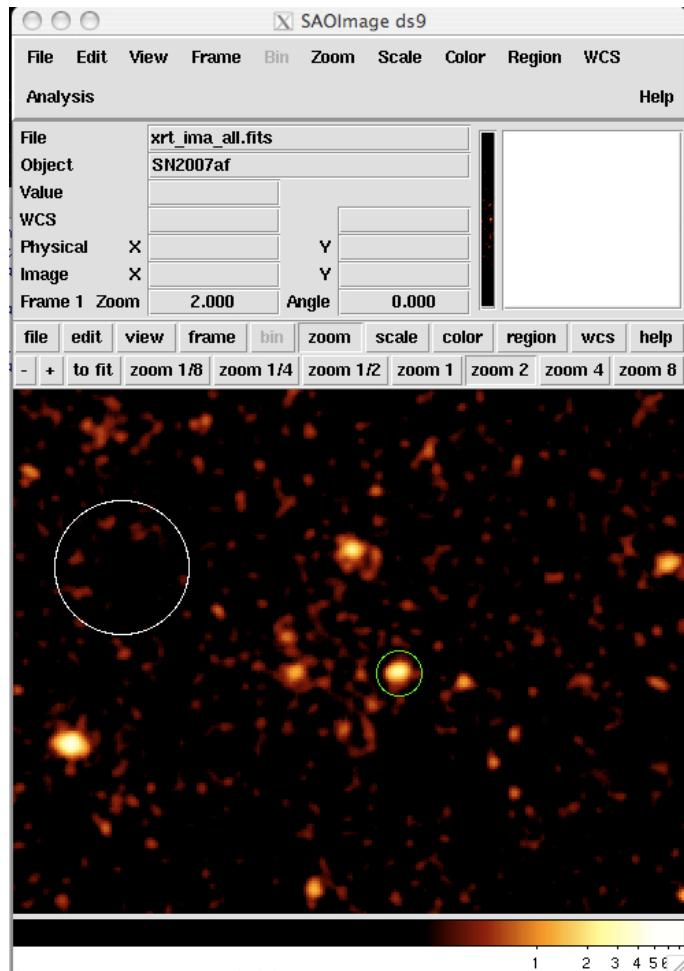
Spectral/Energy Resolution



Timing Resolution

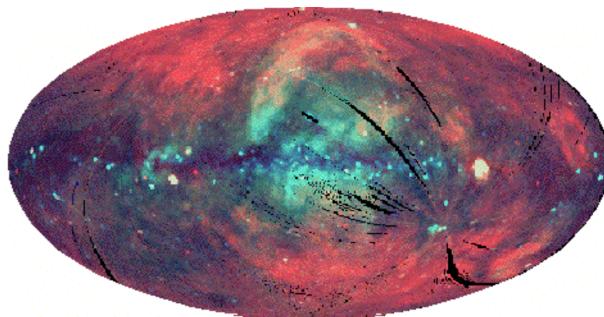


X-Ray Image Analysis

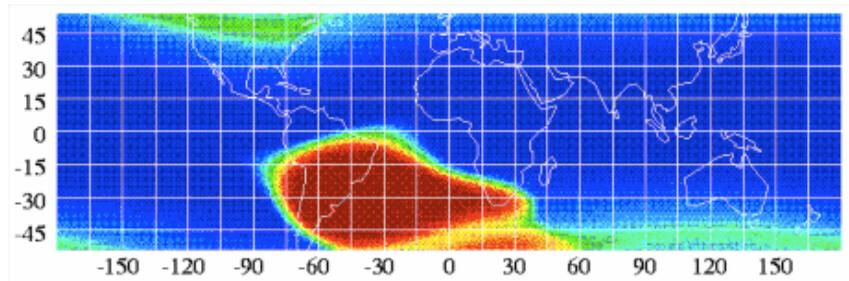


Background

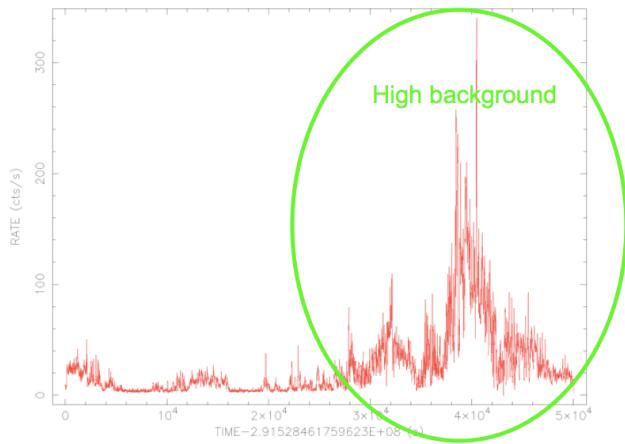
- Sky Background
 - X-rays from unresolved diffuse sources



- South Atlantic Anomaly



- Solar flares



- Instrumental Background
 - Need to understand it
 - Instrument manual
 - Corrected in analysis software

Convert Count Rates to Physical Units

Counting Relation

$$C_{\text{instr}}(I) = \int_{t_1}^{t_2} \int_{E_1}^{E_2} f(E) dt R(I, E) dE + B(I)$$

$C_{\text{instr}}(I)$ = observed counts

$f(E)$ = intrinsic flux from the source

$R(I, E)$ = detector response

$B(I)$ = background counts

WebPIMMS

WebPIMMS

A Mission Count Rate Simulator
Powered by [PIMMS v3.9](#)

Access the multiple component model [interface](#).

Convert From:	Into:															
SWIFT/XRT/PC Count Rate	FLUX															
Examples of Common FLUX Input/Output Ranges																
<u>Input Energy Range</u> (low-high): 0.2-10	<input checked="" type="radio"/> keV <input type="radio"/> Angstroms Units															
<u>Output Energy Range</u> (low-high): 0.2-10	<input checked="" type="radio"/> keV <input type="radio"/> Angstroms Units															
<table border="1"><tr><td>Source: Flux / Count Rate</td><td>1.096E-03</td><td>(erg/cm²/s)</td></tr><tr><td colspan="2"></td><td>(counts/s)</td></tr><tr><td>Galactic nH</td><td>Redshift</td><td>Intrinsic nH</td></tr><tr><td>5.45E+20</td><td>(cm⁻²)</td><td>none</td></tr><tr><td colspan="2"></td><td>(cm⁻²)</td></tr></table>		Source: Flux / Count Rate	1.096E-03	(erg/cm ² /s)			(counts/s)	Galactic nH	Redshift	Intrinsic nH	5.45E+20	(cm ⁻²)	none			(cm ⁻²)
Source: Flux / Count Rate	1.096E-03	(erg/cm ² /s)														
		(counts/s)														
Galactic nH	Redshift	Intrinsic nH														
5.45E+20	(cm ⁻²)	none														
		(cm ⁻²)														
<u>Model of Source:</u>	Model Parameters															
<input type="radio"/> Power Law	Photon index: <input type="text"/>															
<input type="radio"/> Black Body	keV: <input type="text"/>															
<input type="radio"/> Therm. Brems.	kT: <input type="text"/>															
<input checked="" type="radio"/> Raymond-Smith	keV: 10 OR Solar Abundance Ratio <input type="button" value="▼"/> LogT keV <input type="button" value="▼"/>															
<input type="button" value="Estimate Count Rate"/> <input type="button" value="Reset"/>																